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FIBROUS MATERIAL WITH HIGH FUNCTIONAL PARTICLE LOAD

FIELD OF THE INVENTION

This invention relates to fibrous material, including fibrous structures containing particles, which are useful in the manufacture of disposable diapers, adult incontinence pads, sanitary napkins and the like. More particularly, the invention is directed to fibrous articles having very high loads of particles, particularly particles of superabsorbent polymer.

BACKGROUND OF THE INVENTION

Absorbent articles such as disposable diapers, adult incontinence pads, sanitary napkins, panty liners and the like, are generally provided with an absorbent core to receive and retain body liquids. The absorbent core is usually sandwiched between a liquid pervious top sheet, whose function is to allow the passage of fluid to the core, and a liquid impervious backsheet, whose function is to contain the fluid and to prevent it from passing through the absorbent article to the garment of the wearer of the absorbent article.

An absorbent core for diapers and adult incontinence pads frequently includes fibrous batts or webs constructed of defiberized, loose, fluffed, hydrophilic, cellulosic fibers. The core may also include a layer or stratum containing superabsorbent polymer (SAP) particles, granules, flakes or fibers, often referred to as the storage layer or stratum.

In recent years, market demand for an increasingly thinner and more comfortable absorbent article has increased. Such an article may be obtained by decreasing the thickness of the diaper core, by reducing the amount of fibrous material used in the core while increasing the amount of SAP particles, and by calendering or pressing the core to reduce caliper and hence, increase density.

Such higher density cores do not absorb liquid as rapidly as lower density cores because the compacting of the core (densification) results in smaller effective pore size. Accordingly, to maintain suitable liquid absorption, it is necessary to provide a lower density layer having a larger pore size above the high-density absorbent core to increase the rate of uptake of liquid discharged onto the absorbent article. The low-density layer is typically referred to as an acquisition layer. Multiple layer absorbent core designs involve a more complicated manufacturing process.

The storage layer portion of a disposable diaper for example, is generally formed in place, during the converting process, from loose, fluffed cellulose. Such cellulose material is generally not available in preformed roll form because it exhibits insufficient web strength, owing to its lack of interfiber bonding or entanglement, to be unwound directly onto and handled in absorbent pad-making equipment.

Ultra-thin feminine napkins are generally produced from roll-goods based nonwoven material. Such a roll of preformed absorbent core material is unwound directly onto the absorbent article converting equipment without the defiberization step required for fluff-based products, such as diapers and incontinence pads. The nonwoven web is typically bonded or consolidated in a fashion that gives it sufficient strength to be handled in the converting process. These webs may also contain SAP particles.

The web consolidation mechanisms used in the roll-goods approach to making preformed cores provide strength and dimensional stability to the web. Such mechanisms include latex bonding, bonding with thermoplastic or bicomponent fibers or thermoplastic powders, hydroentanglement, needlepunching, carding or the like. At high particle loading, however, the core structures exhibit poor particle containment. In other words, some of the particles tend to escape from the structure during manufacture, handling, shipping and converting and in use. This can result in the fouling of manufacturing and converting equipment as well as negative consumer perception of the product.

There is a need for an absorbent core material which facilitates fluid transport from an acquisition zone to a storage zone, exhibits good particle containment at high particle loading, provides high pliability even at high particle loading, is thin but has a high absorbent

capacity in use, and can be delivered in roll-goods form to simplify the manufacturing and converting processes.

Published PCT application WO 00/71790 discloses an absorbent article including a layer of functional particles, optionally provided in lanes, wherein the lateral edges of the article are free of functional particles and may be sealed to contain loose particles within the structure.

It is an object of the invention to provide a fibrous web comprising functional particles present at high loading, which can be formed into absorbent articles.

It is another object of the invention to provide a method of making a fibrous web including functional particles present at high loading, which can be formed into absorbent articles.

It is another object of the invention to provide an improved fibrous material including a high load of functional particles and exhibits high pliability.

SUMMARY OF THE INVENTION

In one embodiment this invention is a material including

(A) from about 60 weight percent to about 95 weight percent SAP,

(B) from about 5 weight percent to about 40 weight percent fibers,

(C) from about 0.1 weight percent to about 30 weight percent total binder, and

having

(D) a basis weight of from about 100 gsm to about 1000 gsm,

(E) a density of from about 0.15 g/cc to about 3 g/cc, the material having

(F) a thickness Z dimension of from about 0.3 mm to about 3 mm, and

(G) a pliability of about 400 1/N or greater.

In one embodiment the material comprises from about 0.1 weight percent to about 10 weight percent total binder which comprises a first binder, a second binder, and, optionally, a third binder, where each binder can be the same as or different from any other binder. The material may further comprise (H) a carrier, which may be a cellulosic tissue carrier or a synthetic material. The material may further comprise

(I) a layer consisting essentially of

(a) synthetic fibers, and

(b) a third binder.

In one embodiment the material has

(J) a machine direction X dimension of from about 1 cm to about 1000 m,

(K) a cross machine direction Y dimension of from about 2 cm to about 5 m, and the material is in a substantially rectangular format and from about 90 weight percent to about 100 weight percent of the SAP in the material is located in SAP domains with a longest dimension aligned substantially in the machine direction X of the material.

In another embodiment this invention is a nonwoven material with a pliability of about 400 1/N or greater comprising from about 75 to about 95 weight percent SAP.

In another embodiment this invention is a process for the production of a material comprising depositing on a removable support, a carrier or on a carrier on a support a mixture of SAP, fibers and binder, where the material comprises from about 60 weight percent to about 95 weight percent SAP and has a pliability of about 400 1/N or greater.

Preferred aspects are those wherein:

(a) a layer of fibers and binder is deposited on a moving removable support, a carrier or on a carrier on a support to form a web, the movement being in a machine direction X,

(b) SAP is deposited in discreet lanes on the web of (a) in the machine direction, the lanes being spaced apart in the cross machine direction Y at a right angle to the machine direction,

(c) a second layer of fibers and binder is deposited on the moving web,

(d) a second layer of SAP is deposited in discrete lanes on the web of (c) in the machine direction, the lanes being spaced apart in the cross machine direction, where the SAP lanes of the second layer are not superimposed on the SAP lanes of the first layer when viewed from a thickness direction Z at right angles to the X and Y directions,

(e) optionally repeating steps (c) and (d) one or more times,

(f) heating the web one or more times to activate the binder, and

(g) optionally densifying the web.

In another embodiment this invention includes an absorbent core having:

(1) a material of one referred to above in combination with

(2) a second material,

where the second material is a second layer of the material of (1), a material referred to above which is not the material of (1), or a second material which is not a material referred to above. The absorbent core may two of the materials of the invention or one or more of the materials of the invention in combination with a conventional unitary core, an acquisition distribution structure or some other structure. Structures of this type may be referred to as DUOCORE structures, the conventional aspects of which are generally described in WO 00/41882, which is hereby incorporated by reference in its entirety.

The material of the invention as well as a core of this type can be produced in a continuous process which is a series of unit operations, preferably including unit operations involving airlaying of fibrous mixtures through individual airlaying heads. The absorbent core may also be produced with adhesives in a conventional converting operation.

The materials of this invention and cores containing them are useful in various fields including us in absorbent products in the form of a diaper, training pant, incontinent device, feminine hygiene device, surgical drape, wound dressing, or cable wrap.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a top view of a functional particle stratum made according to the present invention, showing multiple lanes of particle material, forming particle-free zones or spaces.

Figure 2 is a top view of a functional particle stratum made according to the present invention, showing multiple lanes of particle material, forming particle-free zones or spaces. Here the lanes are offset from the lanes of the stratum of Fig. 1.

Figure 3 is a cross-sectional view of a fibrous web or article made according to the present invention showing alternating matrix fiber strata and functional particle strata.

Figure 4 is a top view of a functional particle stratum made according to the present invention, showing multiple lanes of particle material, wherein the lanes are S-shaped.

Figure 5 is a top view of a functional particle stratum made according to the present invention, showing multiple lanes of particle material, wherein the lanes are hourglass-shaped.

Figure 6 is a top view of a functional particle stratum made according to the present invention, showing multiple lanes of particle material, wherein the lanes are circle-shaped.

Figure 7 is a top view of a functional particle stratum made according to the present invention, showing multiple lanes of particle material, wherein the lanes are intermittent.

Figure 8 schematically shows a production line for a method of forming absorbent articles comprising an absorbent core according to the present invention. Figure 8a is a cross-sectional view of the production line of Figure 8.

Figure 9 is a schematic view of a lane divider.

Figure 10 is a schematic view of a test apparatus for acquisition/rewet/wicking distance test.

Figure 11 is a schematic view of the folding of an absorbent core of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

All patent and patent applications cited in this specification are hereby incorporated by reference into this specification. In case of conflict in terminology, the present disclosure controls.

The present invention is directed to a stratified fibrous web which comprises a plurality of functional particle strata. Each functional particle stratum includes lanes or zones of functional particles, and each lane or zone is separated from an adjacent lane or zone. Adjacent functional particle strata are oriented such that when viewing the web in the Z-direction, the functional particle lane or zone of one functional particle stratum does not directly overlay, or superimpose, a functional particle lane or zone from the next adjacent functional particle stratum. In other words, the lanes or zones for a first functional particle strata are offset from the lanes or zones of the next adjacent functional particle strata.

With reference to Fig. 1, there is shown a top view of a functional particle stratum. In a preferred embodiment, the structures of the present invention are prepared using airlaid technology. For purposes of reference, the Figures show the structures of the present invention as elongated in the MD or machine direction, also referred to as the Y-direction. The CD or cross-direction is perpendicular to the MD. Finally, the Z-direction refers to the thickness of the structure and is orthogonal to the X-Y plane.

Stratum 2 of Fig. 1 includes a plurality of lanes 6 and 8 extending longitudinally in the Y-direction. Each lane includes functional particles. The edges 10 of stratum 2 are free of functional particles. Between each lane are spaces 14, also free of functional particles. Stratum 2 may be applied over another functional particle stratum or over another stratum not containing functional particles. Referring to Fig. 2, a second functional particle stratum 4 is shown. This stratum also includes longitudinally extending lanes of functional particles. However, the lanes are positioned such that when stratum 2 is applied over stratum 4 the lanes will not superimpose, when viewed in the Z-direction. Similarly, the lanes of stratum 2 will not superimpose over the lanes of stratum 4, even when an intervening stratum not containing functional particles is placed between strata 2 and 4.

The spaces 14 between lanes in strata 2 and 4, preferably are substantially free of functional particles, fibers or any other material. Optionally, non-functional material such as fibers may be provided between the lanes. During the manufacturing process, some minor portion of the particles may migrate from the lanes to the spaces before the fibers are fixed in place by curing of fibers, without adverse effect.

With reference to Fig. 3, there is shown a cross-section (taken in the X-direction) of a multistrata structure according to the present invention including a plurality of functional particle strata. A first stratum 16 not containing functional particles, and preferably containing matrix fibers and a binder is provided. Over stratum 16 is provided stratum 4, including lanes 12 of functional particles with spaces 14 between the lanes free of particles or fibers. Stratum 18 is provided over stratum 4. Stratum 2 is then positioned over stratum 18 such that lanes 6 and 8 of the stratum do not superimpose on the lanes of stratum 4. Again, it is preferred that spaces 14 of stratum 2 are free of particles or fibers. Stratum 20 is provided over stratum 2. Another stratum 4 is positioned over stratum 20 such that lanes 12 do not superimpose on lanes 6 or 8 of stratum 2. Finally, stratum 22 is provided over stratum 4. Each of strata 18, 20 and 22 contains no functional particles and contains the same or different types and amount of fibers as either strata or each other.

The resultant multistrata structure includes alternating strata of fibers and functional particles, such that the lanes of functional particles are substantially surrounded by fibers.

The lateral edges of the multistrata structure of Fig. 3 are optionally provided with an edge seal as described in PCT application WO 00/71790 the disclosure of which is hereby incorporated by reference.

The multistrata structure of Fig. 3 is depicted for illustrative purposes as having three functional particle strata. However, the structure may contain as few as two such strata or as many as is suitable for a particular application. In a preferred embodiment, six such strata are provided.

The multistrata structure of Fig. 3 may itself be included with other strata in a unitary multilayer structure, to provide for example, a structure having specified fluid acquisition, distribution and storage capabilities.

Lanes

The lanes of the functional particle strata are shown in Figs. 1-3 as being parallel and extending continuously in the MD or Y-direction of the strata. However, lanes or zones (hereinafter collectively referred to as "lanes") may be arranged in other ways suitable to the present invention. For example, the lanes can remain as parallel but the particles may be provided intermittently to provide lane segments with gaps between the segments, as shown in Fig. 7. Alternatively, the lanes can be applied in a S-shape in the longitudinal direction with S-shaped spaces between the lanes, as shown in Fig. 4. Alternatively, the lanes may be hour-glass shaped, as shown in Fig. 5. Other patterns may be used as well, such as circle-shaped (Fig. 6). However, it is important that each functional particle stratum contain both lanes containing functional particles and spaces not containing functional particles, and the pattern must be arranged such that lanes or zones of a first functional particle stratum will not superimpose over the lanes or zones of a second next adjacent functional particle stratum. Notwithstanding the foregoing, superimposition of a small percentage (less than 15%) of the area of lanes or zones, is considered to meet this definition.

The preferred amount of coverage of a given functional particle stratum by the functional particles depends upon the application and the thickness, density and other parameters of the particles. Generally, it is preferred that the lanes of the stratum cover at least 30% and preferably 40% and most preferably 50% of the X-Y area of the stratum.

Functional Particles

The functional particle lane is intended to receive particles, flakes, powder, granules, or the like.

The particles may include any functional powder or other particles having a particle diameter of up to 3,000 microns (μ). The particle area may include a particle loading of from 2 to 2,000 gsm (grams per square meter), more preferably from 2 to 1,000 gsm, even more preferably from 10 to 600 gsm, and most preferably from 100 to 250 gsm.

The particles may be superabsorbent polymers ("SAP") or other functional material. Other suitable particles include odor control agents, e.g., zeolites or calcium carbonate, fragrances, detergents and the like.

A superabsorbent polymer is a water soluble compound that has been cross-linked to render it water insoluble but still swellable to at least about 15 times its own weight in physiological saline solution. These superabsorbent materials generally fall into three classes, namely starch graft copolymers, cross-linked carboxymethylcellulose derivatives, and modified hydrophilic polyacrylates. Examples of absorbent polymers include hydrolyzed starch-acrylontrile graft co-polymer, saponified acrylic acid ester-vinyl co-polymer, modified cross-linked polyvinyl alcohol, neutralized cross-linked polyacrylic acid, cross-linked polyacrylate salt, and carboxylated cellulose. The preferred superabsorbent materials, upon absorbing fluids, form hydrogels.

The superabsorbent polymer materials have relatively high gel volume and relatively high gel strength as measured by the shear modulus of the hydrogel. Such preferred materials also contain relatively low levels of polymeric materials which can be extracted by contact with synthetic urine. Superabsorbent polymers are well-known and are commercially available. One example is a starch graft polyacrylate hydrogel marketed under the name IM1000 (Hoechst-Celanese, Portsmouth, VA). Other commercially available superabsorbent polymers are marketed under the trademark Sanwet (Sanyo Kasei Kogyo Kabushiki, Japan), Sumika Gel and SA60S (Sumitomo Kagaku Kabushiki Haishi, Japan), Favor (Stockhausen, Garyville, LA), Kolon GS3500 superabsorbent polymer granules, Kolon, Korea; and the ASAP series (Chemdal, Aberdeen, MS). Superabsorbent particulate polymers are also

described in detail in U.S. Patents 4,102,340 and Re. 32, 649. An example of a suitable SAP is surface cross-linked acrylic acid based powder such as Stockhausen 9350 or SX FAM 70 (Greensboro, NC).

Fibers

The fibers suitable for use in the structures of the present invention may include cellulosic or synthetic fibers or blends thereof. Most preferred is wood cellulose. Also preferred is cotton linter pulp, chemically modified cellulose such as crosslinked cellulose fibers and highly purified cellulose fibers, such as Buckeye HPF (each available from Buckeye Technologies Inc., Memphis, Tennessee). The fluff fibers may be blended with synthetic fibers, for example polyester such as PET, nylon, polyethylene or polypropylene.

The fiber-containing strata may also include thermoplastic binding material, which may be blended with the cellulosic or synthetic fibers. Suitable thermoplastic binding material includes thermoplastic fibers, such as bicomponent thermoplastic fibers ("bico"). Preferred thermoplastic binding fibers provide enhanced adhesion for a wide range of materials, including synthetic and natural fibers, particles, and synthetic and natural carrier sheets. An exemplary thermoplastic bico fiber is Celbond Type 255 Bico fiber from Hoechst Celanese.

Other suitable thermoplastic fibers include polypropylenes, polyesters, nylons and other olefins, or modifications thereof. A preferred thermoplastic fiber is FiberVisions type AL-Adhesion-C Bicomponent Fiber, which contains a polypropylene core and an activated copolyolefin sheath.

When the matrix fibers are cellulosic or synthetic fibers (or blends thereof), each stratum positioned between the functional particle strata may preferably contain from about 1 to 20 gsm of cellulosic of synthetic fibers. A thermoplastic bonding material may be present in the stratum in the amount of 2 to 50% by weight, more preferably 3 to 20%, most preferably about 10% of the total weight of the stratum. Most preferably, the stratum between the functional particle strata includes 3.0 gsm fluff pulp and 1.0 gsm of bico.

Binders

Aside from the thermoplastic fibers discussed above, other suitable binders for use in the structures of the invention include binders in liquid form or having a liquid carrier, including latex binders. Useful latex binders include vinyl acetate and acrylic ester copolymers, ethylene vinyl acetate copolymers, styrene butadiene carboxylate copolymers, and polyacrylonitriles, and sold, for example, under the trade names of Airbond, Airflex and Vinac of Air Products, Inc., Hycar and Geon of Goodrich Chemical Co., and Fulatex of H. B. Fuller Company. Alternatively, the binder may be a non-latex binder, such as epichlorohydrin and the like.

The invention contemplates two separate binder applications. In the first application, the binder is applied to the structure so as to contact only the particle free area or lane, which is adjacent the areas or lanes containing the particles disposed between the first and second layers. The binder may be applied in the form of a spray, foam, or mist. In preferred embodiments, the binders are diluted to contain 3 to 25 % solids, more preferably 6 to 12% solids, most preferably 10%.

A binder which is diluted to have a relatively high solids content (such as 10%) is ideal for acting in the highly compacted, small pore environment of the particle free area, wherein the seals are formed. The environment results in fast wicking, and the high solids content reduces migration of the binder to the other areas of the web.

The second binder application involves application of a binder, in the form of a foam, spray or mist, to substantially the entire surface of the structure (as an "overall binder"), in order to reduce dust-off on the exterior and interior of the structure. In preferred embodiments, the overall binders are diluted to contain 1 to 20 % solids, more preferably 2 to 10% solids, even more preferably 2 to 4% solids, and most preferably about 3.5% solids. While the binder will penetrate to reduce dust-off and to immobilize the functional particles, it will not provide a significant contribution to the structural integrity of the web.

The use of two binder applications allows independent control of the seal area stiffness and the non-seal area stiffness. The stiffness of either region can be controlled by the selection of binder type, solids content and amount of binder applied to the respective regions. This addresses the need to deliver requisite seal strength and maintain sufficient flexibility for the comfort of the user.

Seals

The fibers of the structures of the present invention may be fixed in place to provide integrity to the structure using heat-activated fibers or other binding agents. In certain embodiments a thermoplastic binding material is used and seals are formed when the structure is compacted or densified by pressure or pressure and heat. The seals may be further strengthened by subsequent curing in a curing oven. It is preferred to use thermoplastic fibers as the binder fiber, and heat as the curing agent. Heat can be applied to cure the fibers at the end of the airlaying process, or alternatively, periodically at various stages of the process.

In an alternative embodiment, the sealing may be provided by the application of a liquid binder (or binder in a liquid carrier), after compacting or densification of the web. In such embodiments, the binder is targeted to contact the particle-free areas, and to avoid the particle areas. The binder wicks into the densified region, and forms seals upon drying and curing. Further, in these embodiments, the upper and lower strata optionally contain a thermoplastic binding material.

In another embodiment, seals are formed by application of a liquid binder (or a binder in a liquid carrier) in the particle free zone only, wherein the binder wicks into the densified region and forms strong seals upon drying and curing, without densification of the particle free zone.

In preferred embodiments, seals are formed by compacting or densification of the particle-free areas, followed by application of a binder which is targeted to contact the particle-free areas, and to avoid the particle areas. The binder wicks into the densified region, and forms seals upon drying and curing. In these preferred embodiments, the upper and lower strata each contain a thermoplastic binding material, which strengthens the seals upon densification and curing.

The heat seals are substantially free of functional particles, and the resultant seal is stronger than a seal having particles at the seal interface. When the structure of the invention is subjected to a liquid insult, there are substantially no particles (such as SAP particles) within the sealed area which can swell and disrupt the integrity of the seal.

In certain embodiments of the invention, the article is an absorbent article. The fibrous structure having improved particle containment may be delivered in roll-goods form, or in other packaging formats such as festooning, and is particularly useful as an absorbent core for disposable absorbent articles such as diapers, adult incontinence pads and briefs, and feminine sanitary napkins.

Airlaid Manufacture of a Structure of the Invention

Preferably, the structure of the present invention is prepared as an airlaid web. The airlaid web is typically prepared by disintegrating or defiberizing a cellulose pulp sheet or sheets, typically by hammermill, to provide individualized fibers. The individualized fibers are then air conveyed to forming heads on the airlaid web forming machine. Several manufacturers make airlaid web forming machines, including M&J Fibretech of Denmark and Dan-Web, also of Denmark. The forming heads include rotating or agitated drums, generally in a race track configuration, which serves to maintain fiber separation until the fibers are pulled by vacuum onto a foraminous condensing drum or foraminous forming conveyor (or forming wire). Other fibers, such as a synthetic thermoplastic fiber, may also be introduced to the forming head through a fiber dosing system which includes a fiber opener, a dosing unit and an air conveyor. Where multiple layers are desired, such as a distribution layer and an acquisition layer, separate forming heads may be provided for each type of layer.

In preferred embodiments, the material and structures of the invention contain a carrier tissue. Optionally the use of a compaction roll prior to the introduction of the particle areas can be used to eliminate the need for the tissue.

As contemplated by the present invention, one or more forming heads of the airlaid web forming machine distributes the desired fiber for the lower layer of the absorbent structure.

SAP granules or other particles are then applied to the upper surface of this web. The particles are applied in lanes in the machine direction with particle-free zones or lanes therebetween. Other particles include odor control agents, e.g., zeolites or calcium carbonate, fragrances, detergents and the like.

A second layer is then formed over the top of the lower layer having the particles applied thereto. Another stratum of SAP granules or other particles are then applied to the upper surface in lanes. The lanes are applied such that the granules do not superimpose over the granules in the particle-containing stratum below. Subsequent alternating layers of fibers and granules may be added as desired.

Figure 6 depicts a process of making a fibrous web according to the present invention. Optionally, a carrier tissue 20a may be unwound from the supply roll 21. The tissue 20a is rolled on to screen 18. The tissue may alternatively be used as a carrier or as the lower stratum 16 of the absorbent article. As contemplated for the present invention, a forming head 24 of the airlaid web-forming machine distributes the desired fiber to form the lower stratum 16 of the absorbent structure. Cellulosic fibers may be obtained by disintegrating or defiberizing a cellulose pulp sheet or sheets, typically by hammermill, to provide individualized fibers. The individualized fibers are then air conveyed to forming heads on the airlaid web-forming machine. Cellulosic fiber and optionally thermoplastic fibers are added to the cellulose tissue 20a by forming head 24.

Several manufacturers make airlaid web forming machines, including M&J Fibretech of Denmark and Dan-Web, also of Denmark. The forming heads include rotating drums, or agitators generally in a racetrack configuration, which serve to maintain fiber separation until the fibers are pulled by vacuum onto a foraminous condensing drum or foraminous forming conveyor (or forming wire). For example, in machines manufactured by M&J Fibretech, the forming head includes a rotary agitator above a screen. Other fibers, such as a synthetic thermoplastic fiber, may also be introduced to the forming head through a fiber dosing system, which includes a fiber opener, a dosing unit and an air conveyor. Where multiple strata are desired, such as a fluff pulp distribution stratum and a synthetic fiber acquisition stratum, multiple forming heads are provided, one for each type of stratum.

In a nip formed by a pair of calender rolls 26, the fibers are optionally compressed to the desired thickness and density. The lower stratum 16 may be compacted at this point in the manufacturing process to close the pores of the web if the particles are fine and to prevent spillage on to the forming wire.

Particles are applied to the lower stratum 16 by particle applicator 28. SAP granules or other particles are thus applied to the upper surface of the lower stratum 16. Referring now to Figure 7, the particles are applied in a plurality of lanes 6 in the machine direction with particle-free zones or lanes 8 located between the particle lanes. Lanes are areas in which particles are specifically delivered. Other suitable particles include odor control agents, e.g., zeolites or calcium carbonate, fragrances, detergents and the like.

A second strata of fibers 18 is applied by forming head 34, which applies cellulosic fibers, and optionally can also apply a thermoplastic fiber such as a bicomponent fiber. Subsequent layers can be added on top of the second layer.

After the second stratum is applied the web may pass under another particle applicator 28 (not shown) to apply another stratum of particles, followed by another stratum of fibers applied by another forming head 34 (not shown). In this way, the web may be built up by a desired number of alternating strata of fibers and particles.

A series of ovens is used in processes of the invention, for drying, curing or thermal bonding.

The airlaid web 23 is heated to a temperature in the range of from 125 to 180 °C at oven 50. When thermoplastic fibers are used, including preferably bico fibers, the curing temperature and dwell time must be sufficient to melt the fibers and cause binding. An overall binder is applied to the airlaid web 23 at 52. This binder can be applied by spray, foam or mist, and is applied to reduce dust-off on the surface of the structure.

The air laid web 23 is heated in a second oven 54 at a temperature in the range of from 125 to 180 ° C. The airlaid web 23 can be treated at pressure in the range of from 0.1 to 10 psi, preferably 1.5 psi. As a result of this process, heat seals between the thermoplastic material and the fibers of the upper and lower layers are formed. The heat seals are substantially free of particles (especially SAPs), which could disrupt the heat seal upon exposure to moisture. The finished web is then rolled for future use. This continuous band of fibrous web can be slit or cut to form individual absorbent articles in a cutting unit, which has not been depicted in this figure.

Optionally, the finished web may be slit or perforated at the heat seal to yield narrow slit core material having a heat seal along both edges. The heat seals to be slit must be of sufficient width to provide two effective seals after slitting.

In other embodiments, various other layers containing other types and amounts of fibers may be applied above or below the upper and lower layers of the structure of the present invention. For example, the absorbent article may also contain a fluid previous top sheet and a fluid impervious backsheet. Exemplary absorbent articles which can be formed from absorbent cores of the invention include diapers, feminine sanitary napkins, and adult incontinence products.

Exemplary Embodiments of the Invention

Examples 1, 2, 4 and 5 were manufactured on a airlaid pilot machine made by Danweb which has three forming heads, and to which has been added a between-the-head SAP dosing system. In order to obtain more than three layers, the structures were made by passing the web through the forming process more than once. On each pass the material was slightly pressed at the end of the line. The final thickness was adjusted on the last pass. The SAP powder was placed in discrete lanes with the aid of divider boxes as depicted schematically in Fig. 9. which masks about half of the area of the airlaid forming wire. The dividers in the following Examples were 1.27 cm in width and the spaces between the dividers were 1.27 cm in width.

The raw materials used in the Examples are Foley Fluff (FF), a southern softwood bleached kraft fluff pulp, Buckeye Technologies Inc.; T-255 polyolefin bicomponent fiber, 2.8 dpf, KoSa; 3024 cellulosic carrier tissue, 18 gsm, Cellu Tissue Co; T-224 polyester fiber, 15 dpf x 6 mm, KoSa; Sumitomo SA60S superabsorbent polymer granules, Sumitomo, Japan, Favor 880 superabsorbent polymer granules, Degussa, USA, Kolon GS3500 superabsorbent polymer granules, Kolon, Korea and Airflex 124 latex emulsion, Air Products Chemicals.

The materials of Examples 1, 2, 4 and 5 have a plurality of layers produced in two passes through the three head airlaying machine, with layer 1 made first on the cellulosic carrier, followed by the first SAP feed in lanes, followed by layer 2, followed by a second

SAP feed in lanes, where the lanes of SAP from the second SAP feeder are offset in the cross machine direction from the location of the lanes of SAP from the first SAP feeder, so that, looking at the material from the top down the Z dimension perpendicular to the machine direction and the cross machine direction, the lanes of SAP from successive feeds do not superimpose.

Below is given in reverse order the composition used to produce Examples 1, 2, 4 and 5. SAP amounts in grams per square meter (gsm) for a particular SAP feed are an overall basis weight for that feed. Since the SAP is laid down in lanes, the amount of SAP at successive locations in the cross machine direction varies from zero or about zero between the lanes of SAP to about 100 percent in the lanes.

Example 1: Basis weight 323 gsm, Caliper 1.2 mm

Layer 6: 10 gsm FF, 2.8 gsm bico, 1.0 gsm latex sprayed on top
Between head SAP feeder 5: 52.6 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 5: 3.0 gsm FF, 1.0 gsm bico
Between head SAP feeder 4: 52.6 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 4: 3.0 gsm FF, 1.0 gsm bico
Between head SAP feeder 3: 52.6 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 3: 3.0 gsm FF, 1.0 gsm bico
Between head SAP feeder 2: 52.6 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 2: 3.0 gsm FF, 1.0 gsm bico

Between head SAP feeder 1: 52.6 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1: 9 gsm FF, 3.2 gsm bico

Carrier: 18 gsm cellulosic tissue

Sumitomo SA60S SAP was used in this example.

__Example 2 Basis weight 318 gsm, Caliper 0.9 mm__

Layer 6: 6.0 gsm FF, 1.5 gsm bico, 1.0 gsm latex sprayed on top

Between head SAP feeder 5: 54.4 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 5: 2.0 gsm FF, 0.8 gsm bico

Between head SAP feeder 4: 54.4 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 4: 2.0 gsm FF, 0.8 gsm bico

Between head SAP feeder 3: 54.4 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 3: 2.0 gsm FF, 0.8 gsm bico

Between head SAP feeder 2: 54.4 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 2: 2.0 gsm FF, 0.8 gsm bico

Between head SAP feeder 1: 54.4 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1: 6.2 gsm FF, 2.1 gsm bico

Carrier: 18 gsm cellulosic tissue

Sumitomo SA60S SAP was used in this example.

Example 4: Basis weight 323 gsm, Caliper 1.3 mm

The first pass through the three head airlaid forming system laid the materials in the amounts indicated below in reverse order, starting with Head 1 laying a FF and bico mixture on the cellulosic carrier tissue. In the second pass, layer 4 was laid by Head 3.
Layer 4 (Head 3): 16.8 gsm PET Wellman 213x1 (6dpf), 3.2 latex Airflex 124

Layer 3 (Head 3): 7.0 gsm FF, 3.0 gsm bico
Between head SAP feeder 2: 127.5 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 2 (Head 2): 7.0 gsm FF, 3.0 gsm bico
Between head SAP feeder 1: 127.5 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 7.0 gsm FF, 3.0 gsm bico
Carrier: 18 gsm cellulosic tissue

Sumitomo SA60S SAP was used in this example.

Example 5: Basis weight 383 gsm, Caliper 2.0 mm

The first pass through the three head airlaid forming system laid the materials in the amounts indicated below in reverse order, starting with Head 1 laying a FF and bico mixture on the cellulosic carrier tissue. The second pass started with between head SAP feeder 1, followed by airlaying Layer 4 by Head 2.

Layer 5 (Head 3): 18.1 gsm FF, 7.7 gsm bico

Between head SAP feeder 2: 71.3 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 4 (Head 2): 7.0 gsm FF, 3.0 gsm bico

Between head SAP feeder 1: 71.3 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 3 (Head 3): 7.0 gsm FF, 3.0 gsm bico

Between head SAP feeder 2: 71.3 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 2 (Head 2): 7.0 gsm FF, 3.0 gsm bico

Between head SAP feeder 1: 71.3 gsm SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 14.0 gsm FF, 8.0 gsm bico

Carrier: 18 gsm cellulosic

Degussa FAVOR® 880 SAP was used in this example.

Comparative Example 3

A web was manufactured on the three-head Danweb airlaid machine with the SAP fed through the forming heads. The raw materials used were ND416 compressible pulp, Weyerhaeuser, Tacoma WA; T-255 bicomponent fiber, 2.8 dpf, KoSa; 3024 cellulosic carrier tissue, 18 gsm, Cellu Tissue Co; T-224 polyester fiber, 15 dpf x 6 mm, KoSa; Kolon GS3500 superabsorbent polymer granules, Kolon, Korea; and Airflex 124 latex emulsion, Air Products Chemicals. The basis weight was 318 gsm, and the caliper was 0.9 mm.

Layer 3: 36.0 gsm ND416, 5.0 gsm bico, 61.3 gsm SAP, 2.0 gsm latex sprayed on top

Layer 2: 35.0 gsm ND416, 5.0 gsm bico, 61.3 gsm SAP

Layer 1: 35.0 gsm ND416, 5.0 gsm bico, 61.3 gsm SAP

Carrier: 18 gsm cellulosic

Pliability

As used herein, "pliability" is the inverse of the amount of force necessary to bend a sheet of material of the invention. As the force necessary to bend the sheet increases, the pliability of the sheet decreases.

Pliability can be measured by the following procedure, using a Gurley tester (Model 4171, Gurley Precision Instruments, Troy, NY).

1. Cut sample to 1 inch x 3.25 inch as accurately as possible. If there is a definite machine direction and cross direction, cut one sample in each direction and test each.

2. Fit custom clamp as shown in Fig. 3, over the original clamp provided with the Gurley tester, and tighten smaller, upper thumbscrews to secure (see Figure 2 illustrating the custom clamp for higher basis weight, lofty sheets). The custom clamp was designed in such a way that it does not change the thickness of the tested material, where the material is inserted into the clamp. If the thickness is changed as a result of clamping then the properties of the structure are changed and the results obtained by using the Gurley tester are affected. In the present method, the clamp of Figure 3 is used to eliminate such undesired effects.

3. Open the custom clamp adjustable plate by loosening longer, lower thumbscrews. Place sample in clamp by sliding sample up until it just contacts original clamp. There should be 2.0 inches of sample contained in the custom clamp.

4. Adjust height of custom clamp by loosening height adjustment screw on original clamp. Adjust height so that a gap of 1.0 inch exists between the point where the sample exits the custom clamp and the point where the sample will contact the lever arm.

5. Ensure that the remaining 0.25 inch of sample extends below the top of the lever arm. Ensure that lever arm is not moving. Press motor button to move sample towards lever arm. Continue pressing motor button until sample clears lever arm. While doing this, observe and note the highest number reached on the scale. Repeat this in the opposite direction.

6. Average the two values obtained. In the conversion chart on the apparatus, find the factor for a 1 inch wide x 1.5 inch long sample depending on the weight used and the distance the

weight was placed from the center on the lever arm. A 1.0 inch x 3.25 inch sample tested using the custom clamp corresponds to a 1.0 inch x 1.5 inch sample tested without using the custom clamp. Without the custom clamp, 0.25 inch of sample is in the original clamp, 0.25 inch extends below the top of the lever arm, and 1 inch is the gap between. Using the custom clamp, the same 0.25-inch number in the custom clamp is used; the other 1.75-inch in the custom clamp secures the thicker sample in place. The same 0.25-inch extends below the top of the lever arm and the same one-inch gap is in between.

7. Multiply the average reading on the scale by the appropriate conversion factor found on the chart.

The result is Stiffness, which is expressed in milligrams force, mg. Pliability, P, is defined here according to the following formula:

$$P = 10^6/9.81*\text{Stiffness}.$$

The result, P, is expressed here in 1 per Newton, 1/N.

Table 1 below has data for Examples 1, 2, 4 and 5 of this invention, Comparative Example 3 and for several prior art materials which are used in commercial products.

TABLE 1

Material	Basis weight, gsm	SAP basis weight, gsm	SAP content, %	Pliability, 1/N	Thickness, mm
Example 1	323	263	81	918	1.2
Example 2	318	272	85	1250	0.9
Comparative Example 3	325	184	57	334	2.0
Example 4	233	255	79	486	1.3
Example 5	383	285	74	639	2.0
Competitive airlaid core	553	275	50	40	1.6
Commercial diaper core	590	236	40	122	5.5

Examples 1, 2, 4 and 5: New bonded structures
Example 3: Prior-art bonded structure
Competitive airlaid core: Nova Thin, no binder
Commercial diaper core Huggies, no binder

Example 6: Basis weight 332 gsm, Caliper 2.5 mm, Pliability 265 1/N

This structure was produced in three individual passes through the three head airlaid line. During the first pass, the first forming head deposited a mixture of 21.5 gsm Foley fluff and 2.3 gsm T-255 KoSa 2.8dpf bicomponent fibers onto an 18 gsm forming tissue from Cellutissue. Next 45.0 gsm of Kolon MG2600 from Kolon Chemical company was deposited in lanes onto the web. The second forming head added a mixture of 21.5 gsm Foley fluff and 2.3 gsm T-255 KoSa 2.8dpf bicomponent fibers. After the structure was cured in an oven, 2.0 gsm AF-124 latex foam was added to the tissue side of the absorbent. Basis weight at this point was 113 gsm.

The second pass started by using the structure made in the first pass as the carrier material. The first head added 3.0 gsm Foley fluff and 1.0 gsm T-255 KoSa 2.8 dpf bicomponent fibers. Next 45.0 gsm of Kolon MG2600 from Kolon Chemical company was deposited in lanes onto the web. This addition of SAP to the web was aligned so the SAP lanes in the first structure were not directly below. The second forming head added a mixture of 21.5 gsm Foley fluff and 2.3 gsm T-255 KoSa 2.8 dpf bicomponent fibers. Again, 45.0 gsm of Kolon MG2600 from Kolon Chemical company was deposited in lanes onto the web. This addition of sap to the web was aligned so the first sap lanes were not directly below the second. The third head deposited a mixture of 21.5gsm Foley fluff and 2.3 gsm T-255 KoSa 2.8 dpf bicomponent fibers.

The third pass started by using the structure made in the second pass as the carrier material. Only the third head was used in this pass. The third head added a mixture of 27.0 gsm Wellman 213X1 6 dpf polyester fibers and 53.0 gsm AL-Delta 6.7dtx fibers from ES Fiber Visions. The final thickness was reached by compaction of the web to 2.5 mm. The basis weight was 332 gsm.

Example 7: Basis weight 140 gsm, Caliper 2.2 mm, Pliability 868 1/N

This structure was produced in two individual passes through the three head airlaid line.

During the first pass, the first forming head deposited a mixture of 20.0 gsm Foley fluff and 2.0 gsm T-255 KoSa 2.8 dpf bicomponent fibers onto an 18 gsm forming tissue from Cellutissue. Next 30.0 gsm of Kolon MG2600 from Kolon Chemical company was deposited in lanes onto the web. The second forming head added a mixture of 21.0gsm Foley fluff and 2.0 gsm T-255 KoSa 2.8 dpf bicomponent fibers. Basis weight was 93 gsm at this point.

The second pass started by using the structure made in the first pass as the carrier material. Only the third head was used in this pass. The third head added a mixture of 17.0 gsm Wellman 213X1 6 dpf polyester fibers and 33.0 gsm AL-Delta 6.7dtx fibers from ES Fiber Visions. The final thickness was reached by compaction of the web to 2.2 mm. The basis weight was 140gsm.

Example 8: Absorbent Core Thickness 4.12mm, Pliability 116 1/N

An absorbent core was made by joining the material of Example 7 as an upper layer ASP (acquisition and storage ply) with the material of Example 5 as a lower layer DSP (distribution and storage ply) in a DUOCORE absorbent core structure. The materials were joined by means of a polymer spray adhesive, Super 77 available from 3M, St. Paul, MN. The area of the ASP was less than that of the DSP. An alternative version of this core with no adhesive was made as part of the acquisition time test procdure which follows.

Acquisition Time / Rewet / Wicking Distance Test Method

Equipment

Saline solution, 0.9% (0.9% NaCl / deionized water by weight). Add food-grade dye for better visibility if desired.

Analytical balance, accurate/precise to +/- 0.01 g.

Timer graduated in seconds.

Stopwatch graduated in hundredths of seconds.

Plastic insult tube, 3.8 cm inside diameter (ID) x 15.2 cm long (1.5 in ID x 6 in).

Foam, 40.6 cm long x 10.2 cm wide x 3.8 cm high (16 in x 4 in x 1.5 in). The foam should have a hole cut into it. The center of the hole should be located 10.2 cm from one of the ends (lengthwise) and centered widthwise. The hole should have a diameter just large enough to accommodate insertion of the plastic insult tube. The foam should be covered with flexible plastic sheeting and sealed in any appropriate way (heat seal, waterproof tape, etc.) such that a waterproof barrier is created around the foam. Foam can be purchased from Scott Fabrics, Memphis, TN.

Gray weight plates, 40.6 cm long x 10.2 cm wide (16 in x 4 in). The plates should weigh 2.9 kg (6.4 lb) to achieve a 0.69 kPa (0.1 psi) load. Each plate should have a hole the same size and at the same location as the hole in the foam piece.

Black weight plate, 40.6 cm long x 10.2 cm wide (16 in x 4 in), weighing enough to achieve a 0.69 kPa (0.1 psi) load when the foam is used in conjunction with the plate. The plate should have a hole the same size and at the same location as the hole in the foam piece.

Plastic board, 20.3 cm x 43.2 cm (8 in x 17 in).

Coverstock material, polypropylene spunbond treated with a durable hydrophilic finish, 22 gsm. The coverstock material can be purchased from Avgol Nonwoven Industries, Holon, Israel.

Blotter paper, Grade S-22, cut to 40.6 cm long x 10.2 cm wide (16 in x 4 in). The Grade S-22 paper can be purchased from Buckeye Technologies, Memphis, TN.

Ruler graduated in millimeters.

Cylinder, graduated in tenths of milliliters.

Procedure

Assemble the sample (Duocore system) by placing ASP upper ply, cut to 10 cm x 20 cm, over one end of DSP lower ply, cut to 10 cm x 40 cm. Note that the polyester fiber layer of the ASP should face up and the tissue side of the DSP should face down.

Place the sample in the test apparatus by placing sample on plastic board. Place the coverstock material over the sample. Insert the plastic insult tube into the foam. Position the foam piece on top of the sample; the insult tube should be located over the ASP upper ply.

Place one black weight and three gray weights over the foam piece to achieve a 2.7 kPa (0.4 psi) load on the sample. Figure 6 contains a schematic diagram of the test apparatus.

Set the timer for 20 minutes and place it beside the test apparatus.

With the stopwatch in one hand and the graduated cylinder containing 75 ml of saline solution in the other hand, prepare to insult the sample. Pour the fluid into the plastic insult cylinder. Start the stopwatch at the moment the fluid strikes the sample. Empty the fluid from the graduated cylinder as quickly as possible. Stop the stopwatch when the fluid is absorbed by the sample.

Record the time taken by sample to absorb fluid as the acquisition time for the first insult.

Start the 20-minute timer as soon as the fluid is absorbed by the sample. Wait for 20 minutes.

After the 20-minute waiting period, repeat steps 3 – 5 two more times on the same sample in order to measure the acquisition times for the second and third insults.

After the third 20-minute waiting period, set the timer for 5 minutes and place it beside the test apparatus.

Weigh a stack of 10 S-22 blotter papers. Record weight.

Remove the weight over sample, the foam piece and the insult cylinder.

Place the stack of papers on the sample.

Replace the foam and weights over the sample. Start the 5-minute timer.

At the end of 5 minutes, remove the weight and foam. Reweigh the stack of papers. Record this second (wet) weight. The rewet, expressed in grams, is the difference between the wet weight of the papers and the dry weight of the papers.

Find the furthest point fluid wicked to one end of the sample and draw a line across the width of the sample at that point. Repeat the same at the other end of the sample.

Measure the distance in cm between the two lines. Record this number as the wicking distance.

The result for this core was a 1st insult acquisition time of 49.2 seconds, 2nd of 104 seconds and third of 129 seconds.

Example 9: Absorbent Core Thickness 4.83 mm, Pliability 135 1/N

This core was made by the procedure used in Example 8, except that the ASP was the material of Example 6 and the SAP was the material of Example 5. The result for this core was a 1st insult acquisition time of 42.9 seconds, 2nd of 80 seconds and third of 102 seconds.

Various materials, structures and manufacturing processes useful in the practice of this invention are disclosed in U.S. Patent No.'s 6,241,713; 6,353,148; 6,353,148; 6,171,441; 6,159,335; 5,695,486; 6,344,109; 5,068,079; 5,269,049; 5,693,162; 5,922,163; 6,007,653; and 6,355,079; and in U.S. Patent applications with serial numbers and filing dates, 09/211,935 filed 12/15/98; 09/232,783 filed 1/19/99; 09/719,338 filed 1/17/01; 09/475,850 filed 12/30/99; 09/469,930 filed 12/21/99; 09/578,603 filed 5/25/00; 05/593,409 filed 6/14/00; 09/325,764 filed 6/8/99 allowed; 09/774,248 filed 1/30/01; and 09/854,179 filed 5/11/01, all of which are hereby incorporated by reference in their entirety.

Table 2 Examples 11-15

Example	Basis Weight, gsm	SAP Content, %	Pliability, 1/N	Thickness, mm
11	250	75	3250	1.1
12	250	75	2760	1.1
13	420	80	810	1.4
14	420	80	920	1.4
15	250	75	1900	1.1

Examples 11 through 15

All examples were manufactured on a 3-head airlaid pilot Danweb machine with between-head SAP dosing systems. Examples 13 and 14 were formed in two stages. On the first pass through the forming process, part of the web was formed, and then on the second pass the

remaining part of the structure was formed. On each pass the material was slightly pressed at the end of the forming line. The final thickness was adjusted on the last pass. The SAP powder was placed in discrete lanes along the machine direction (MD). The lanes were formed with the aid of divider boxes depicted in Figure 9 of the original application. The divider boxes were used that masked 50% of the area of an airlaid forming wire. The dividers were 1.27 cm in width and the voids between the dividers were 1.27 cm in width. With this divider box, the same amount of SAP can be distributed over half of the area, resulting in SAP stripes of twice the overall basis weight.

Any conventional means of dosing SAP onto an airlaid forming wire may be used with the divider box shown in Figure 9.

Raw materials :

FOLEY FLUFF®, southern softwood bleached kraft fluff pulp, Buckeye Technologies Inc.

Treated FOLEY FLUFF®, as described in U.S. Patent Application serial no. 09/469,930 filed 12/21/99, available from Buckeye Technologies Inc. under the brand name CARESSA(TM),

T-255 bicomponent fiber, 2.8 dpf, KoSa

3024 cellulosic carrier tissue, 18 gsm, Cellu Tissue Co.

10 gsm Avgol hydrophobic nonwoven carrier, Avgol, Israel

Stockhausen SXM70 superabsorbent polymer granules, Degussa, USA

Airflex 124 latex emulsion, 10% solids, Air Products Chemicals mixed with 0.1% Aerosol OT

Example 11

Latex spray applied on the top of the structure in an amount of 2 gsm (dry weight).

Layer 3 (Head 3): 12.0 gsm FF, 5.0 gsm bico

Between head SAP feeder 2: 94 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 2 (Head 2): 6.5 gsm FF, 2.5 gsm bico

Between head SAP feeder 1: 94 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 11 gsm FF, 5.0 gsm bico

Carrier: 18 gsm cellulosic

* Overall basis weight

Example 12

Latex spray applied on the top of the structure in an amount of 2 gsm (dry weight).

Layer 3 (Head 3): 12.0 gsm FF, 5.0 gsm bico

Between head SAP feeder 2: 98 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 2 (Head 2): 6.5 gsm FF, 2.5 gsm bico

Between head SAP feeder 1: 98 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 11 gsm FF, 5.0 gsm bico

Carrier: 10 gsm Avgol nonwoven

*Overall basis weight

Example 13

Pass I:

Layer 6 (Head 3): 16.5 gsm FF, 5.0 gsm bico

Between head SAP feeder 2: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 5 (Head 2): 5.7 gsm FF, 2.2 gsm bico

Between head SAP feeder 1: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

Layer 4 (Head 1): 9.6 gsm FF, 4.4 gsm bico

Carrier: 18 gsm cellulosic

* Overall basis weight

Pass II:

Latex spray applied on the top of the structure in an amount of 2 gsm (dry weight).

Layer 3 (Head 3): 16.5 gsm FF, 5.0 gsm bico

Between head SAP feeder 2: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

<u>Layer 2 (Head 2)</u>: 5.7 gsm FF, 2.2 gsm bico

<u>Between head SAP feeder 1</u>: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

<u>Layer 1 (Head 1)</u>: 9.6 gsm FF, 4.4 gsm bico

* Overall basis weight

<u>Example 14</u>

Pass I:

<u>Layer 6 (Head 3)</u>: 16.5 gsm FF, 5.0 gsm bico

<u>Between head SAP feeder 2</u>: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

<u>Layer 5 (Head 2)</u>: 5.7 gsm FF, 2.2 gsm bico

<u>Between head SAP feeder 1</u>: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

<u>Layer 4 (Head 1)</u>: 13.6 gsm FF, 4.4 gsm bico

<u>Carrier</u>: 10 gsm Avgol nonwoven

* Overall basis weight

Pass II:

Latex spray applied on the top of the structure in an amount of 2 gsm (dry weight).

<u>Layer 3 (Head 3)</u>: 16.5 gsm FF, 5.0 gsm bico

<u>Between head SAP</u> feeder 2: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

<u>Layer 2 (Head 2)</u>: 5.7 gsm FF, 2.2 gsm bico

<u>Between head SAP feeder 1</u>: 78.3 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

<u>Layer 1 (Head 1)</u>: 13.6 gsm FF, 4.4 gsm bico

* Overall basis weight

<u>Example 15</u>

Latex spray applied on the top of the structure in an amount of 2 gsm (dry weight).

<u>Layer 3 (Head 3)</u>: 12.0 gsm SW-16, 5.0 gsm bico

Between head SAP feeder 2: 94 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart.

(the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 2 (Head 2): 6.5 gsm SW-16, 2.5 gsm bico

Between head SAP feeder 1: 94 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 11 gsm SW-16, 5.0 gsm bico

Carrier: 18 gsm cellulosic

* Overall basis weight

Effect of Folding of Absorbent Core on Its Acquisition Properties

It was discovered that folding of structures described in the invention results in significant improvement in their acquisition properties. This improvement is illustrated with but not limited to the examples summarized in Table 3. Based on these results we can see improvements of the performance of the folded structures over the unfolded samples having the same overall basis weight as the folded ones in the folded configuration (see Fig. 11). These improvements are significantly shorter acquisition times and also lower rewet values.

Table 3

Example	BW, gsm		SAP		Fluid Intake Time, s		Rewet
	Unfolded	Overall BW after C-folding*)	Type	%	1st	2nd	g
11 C-folded (see Fig. 11)	250	420	SXM70	75	176	422	12.3
13	420	-	SXM70	75	1594	3600	13.9
12 C-folded (see Fig. 11)	250	420	SXM70	75	225	327	9.2
14	420	-	SXM70	75	1354	3147	20.2

*) C-folding:

A 21.7cm wide by 66 cm long material, each edge was folded over approximately 4.3cm dividing the layer into thirds (4.3cm folded, 4.3cm unfolded open, 4.3cm folded) for a total width of about 13cm (see cross-sections folded and unfolded sheets, Fig. 11)

3. Effect of Treated FOLEY FLUFF® (TFF) on Capacity and Acquisition

MoliCare Plus AI diapers from Hartmann were used as control products. The absorbent is in three layers, curly fiber acquisition layer, sap-fluff layer and a fluff back layer against the poly backsheet. The diapers were taken apart by carefully peeling the fluff back layer from the sap-fluff layer. Then the SAP-fluff layer was peeled from the coverstock and curly fibers. The airlaid core was then placed on the fluff back layer and covered by the curly fibers and topsheet. The curly fibers were not removed from the topsheet. One of the inserted cores, that is Example 11, contained FOLEY FLUFF®as cellulosic fiber component and the other

contained Treated FOLEY FLUFF®. The width of the airlaid inserts in the obtained Absorbent Systems 1 was 13 cm and their length was 66 cm.

The results in Table 4 illustrate the effect of the Treated FOLEY FLUFF® on the performance of the Absorbent System 1 composed of the topsheet, curly-fiber layer, airlaid insert, fluff and poly backsheet. As seen from the data, the acquisition of Example 15 with Treated FOLEY FLUFF® was significantly faster than the acquisition of Example 11 with FOLEY FLUFF®. The sample with SW-16 fibers had also improved capacity over the sample with FF.

Table 4

Core Material from Example	BW, gsm	SAP		Fiber	Capacity @ 0.4 psi of airlaid inserts only		Absorbent System 1 Fluid Intake Time, s		
		Type	%		13cm x 40.6cm	g/g	1st	2nd	3rd
11	253	SXM70	75	FF	218 (SD 3.8)	16.3 (SD 0.45)	94	287	412
15	252	SXM70	75	TFF	248 (SD 2.5)	18.7 (SD 0.15)	75	239	360

4. Effect of Treated FOLEY FLUFF®on Fluid Intake of Folded High-SAP Airlaid

MoliCare Super AI diapers from Hartmann (as above) were used as control products. In this case the airlaid cores were first C-folded as shown in Fig 11and then placed on the fluff back layer and covered by the curly fibers and topsheet. The curly fibers were not removed from the topsheet. One of the inserted cores, that is C-folded Example 11 contained FOLEY FLUFF® as cellulosic fiber component and the other, Example 15, contained Treated FOLEY FLUFF®. The width of the airlaid inserts was 13 cm and their length was 66 cm. The results in Table 5 illustrate the effect of the Treated FOLEY FLUFF®and C-folding on the performance of the Absorbent System 2 composed of the topsheet, curly-fiber layer, airlaid insert, fluff and poly backsheet. As seen from the data, the acquisition of the C-folded Example 15 with Treated FOLEY FLUFF® was significantly faster than the acquisition of the C-folded Example 11 with FOLEY FLUFF®. The sample with Treated FOLEY FLUFF®fibers had also improved capacity over the sample with FOLEY FLUFF®.

Table 5

Core Material from Example, C-Folded (see Fig. 11)	SAP		Fiber	Absorbent System 2 Fluid Intake Time, s		
	Type	%		1st	2nd	3rd
11	SXM70	75	FF	64	161	265
15	SXM70	75	TFF	50	119	190

Effect of Bonded Acquisition Ply and Treated FOLEY FLUFF®on Fluid Intake of Folded High-SAP Airlaid in Whole Absorbent System

To make a bonded acquisition pad, several MoliCare Super diapers were taken apart and the acquisition pads removed. The removed curly fibers were then used to make an airlaid handsheet using a lab pad blowing apparatus, with an addition of 8% KoSa T-255, 2.8 dpf fibers. The pad was cured at 160C for 10 minutes. These acquisition pads had basis weight of about 159 gsm and their thickness was about 3.8 mm. The basis weight of the unbonded acquisition layers of curly fibers in the original diapers was about 154 gsm and their thickness was about 2.0 mm. They were added to the Molicare Super diaper shell along with Example 15. Example 15was in a C-fold configuration as shown in Fig. 11. The results shown in Table 6 indicate that the Absorbent Systems 2 with C-folded airlaid inserts containing Treated FOLEY FLUFF® fibers and with bonded acquisition layers had better acquisition performance than the original diapers.

Table 6

Example for High-SAP Airlaid Component Unfolded/C-Folded	Curly Fiber Acquisition Ply	Overall Mass of Absorbent System, g	Fiber in High-SAP Airlaid	Absorbent System 2 (see Fig.3) Fluid Intake Time, s		
				1st	2nd	3rd
14 Unfolded	Unbonded	72	FF	67	197	310
11 C-Folded (see Fig. 1)	Unbonded	73	FF	64	161	265
15 C-Folded (see Fig. 1)	Unbonded	73	TFF	50	119	190
15 C-Folded (see Fig. 1)	Bonded	73	TFF	25	61	100
Unbonded Control	Unbonded	114	-	53	108	144

<u>Examples 16 through 18</u>

All examples were manufactured on a 3-head airlaid pilot Danweb machine with 2 between-head SAP dosing systems. The SAP powder was placed in discrete lanes along the machine direction (MD). The lanes were formed with the aid of divider boxes depicted in Figure 9 of the original application. The divider boxes were used that masked 50% of the area of an airlaid forming wire. The dividers were 1.27 cm in width and the voids between the dividers were 1.27 cm in width. With this divider box, the same amount of SAP can be distributed over half of the area, resulting in SAP stripes of twice the overall basis weight.

The structures of Examples 17 and 18 comprise a thicker layer of bonded cellulose fibers for enhanced wicking performance.

Any conventional means of dosing SAP onto an airlaid forming wire may be used with the divider box shown in Figure 9.

Raw materials :

FOLEY FLUFF®, southern softwood bleached kraft fluff pulp, Buckeye Technologies Inc.

Treated FOLEY FLUFF®, as described in U.S. Patent Application serial no. 09/469,930 filed 12/21/99, available from Buckeye Technologies Inc. under the brand name CARESSA(TM),

T-255 bicomponent fiber, 2.8 dpf, KoSa

Carrier: 10 gsm Avgol hydrophilic nonwoven carrier, Avgol, Israel

SAP: Stockhausen Z1102 superabsorbent polymer granules, Degussa, USA

Airflex 124 latex emulsion, 10% solids, Air Products Chemicals mixed with 0.1% Aerosol OT

Example 16

Latex spray applied on the top of the structure in an amount of 5.0 gsm (dry weight).

Layer 3 (Head 3): 20.0 gsm Caressa, 1.5 gsm bico

Between head SAP feeder 2: 94 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 2 (Head 2): 6.5 gsm Caressa, 1.5 gsm bico

Between head SAP feeder 1: 94 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 11 gsm Caressa, 1.5 gsm bico

Carrier: 10 gsm Avgol nonwoven

Latex applied on the bottom of the structure in an amount of 5.0 gsm (dry weight).

* Overall basis weight

Example 17

Latex spray applied on the top of the structure in an amount of 5.0 gsm (dry weight).

Layer 3 (Head 3): 20 gsm Caressa, 1.5 gsm bico

Between head SAP feeder 2: 100 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 2 (Head 2): 6.5 gsm FF, 1.5 gsm bico

Between head SAP feeder 1: 100 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 84 gsm FF, 1.5 gsm bico

Carrier: 10 gsm Avgol nonwoven

Latex applied on the bottom of the structure in an amount of 5.0 gsm (dry weight).

*Overall basis weight

Example 18

Latex spray applied on the top of the structure in an amount of 5.0 gsm (dry weight).

Layer 3 (Head 3): 84 gsm FF, 1.5 gsm bico

Between head SAP feeder 2: 100 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart. (the SAP lanes formed under SAP feeder 2 and the SAP lanes formed under SAP feeder 1 do not superimpose)

Layer 2 (Head 2): 6.5 gsm FF, 1.5 gsm bico

Between head SAP feeder 1: 100 gsm* SAP, placed in 1.27 cm lanes, spaced 1.27 cm apart

Layer 1 (Head 1): 20 gsm Caressa, 1.5 gsm bico

Carrier: 10 gsm Avgol nonwoven

Latex applied on the bottom of the structure in an amount of 5.0 gsm (dry weight).

*Overall basis weight

Table 7

Example	Basis weight, gsm	Content of SAP, %	Thickness, mm	Pliability, 1/N	Capacity @ 0.4 psi, g/g
Example 16	250	75	1.1	3265	21.8
Example 17	335	60	1.3	1340	22.5
Example 18	335	60	1.4	1505	22.8